

## **SUMMARY OF SOIL AND GROUNDWATER CONDITIONS**

BOEING REALTY CORPORATION  
FORMER C-6 FACILITY, PARCEL C  
LOS ANGELES, CALIFORNIA

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## EXECUTIVE SUMMARY

This report summarizes the results of an extensive program of environmental investigations on Parcel C of the Boeing Realty Corporation Former C-6 Facility in Los Angeles, California. The purpose of this project was to identify and delineate the extent of impacted soil and groundwater, remove shallow (less than 12 feet) occurrences of impacted soil, initiate plans for remediation of deep soil and groundwater, and to conduct a screening level risk assessment for the site. The program was conducted under the oversight of the California Regional Water Quality Control Board, Los Angeles Region. The investigation program included 169 soil gas samples, 143 groundwater sampling locations, and over 5,900 soil samples that were used to evaluate the nature and extent of subsurface impacts on Parcel C.

Parcel C occupies approximately 50.5 acres in the east-central portion of the 170-acre Former C-6 Facility. As part of BRC's redevelopment efforts, Parcel C has been cleared of all structures, but it was formerly occupied by seven buildings ranging in size from a 7,500 square foot security office to a 1,000,000 square foot aircraft assembly building. The initial investigation focused on 232 environmental features (EFs) identified as being of potential concern based on a review of historical operations. The environmental features included such areas as paint booths, chemical storage areas, underground storage tanks, and clarifiers. In addition, this investigation addressed "open areas" such as paved parking areas and large interior spaces where no environmental features had been identified.

The majority of the 232 EFs had no indication of significant impact in soil. A complete tally of results from all EFs is provided in the Soil Investigation Report (Haley & Aldrich, 2001e). There were, however, a number of occurrences of shallow soil impact and two occurrences of soil impact that extends into deeper soil. The occurrences of deep soil impact consist primarily of trichloroethylene (TCE) and other volatile organic compounds and are referred to as the "Building 1 area" and the "Building 2 area." The contaminants in shallow soil were more varied and consisted of one or more of the following: arsenic, lead, petroleum hydrocarbons, volatile organic compounds (VOCs), and/or polynuclear aromatic hydrocarbons (PAHs).

VOCs have also been detected in groundwater underlying Parcel C. The highest concentrations of VOCs occur beneath the zones of deep soil impact described above. Lower concentrations are found in a more widespread halo, largely emanating toward the south due to the southerly groundwater flow direction. Groundwater in the Building 1 area contains primarily TCE, with lesser amounts of 1,1,1-trichloroethane, 1,1-dichloroethene and other VOCs. Groundwater in the Building 2 area has been impacted primarily by TCE.

Approximately 9,735 cubic yards of impacted shallow soil were excavated from 33 locations on Parcel C. An iterative risk screening process was used to evaluate where it was necessary to remove soil with concentrations of chemicals that posed a potential health risk. Where



necessary, BRC plans to deal with deep soil impacts using soil vapor extraction (SVE). SVE was selected as the deep soil remedy due to its proven applicability at the site, cost-effectiveness for the removal of VOCs from the vadose zone, and ease of rapid deployment. In July 2001, Haley & Aldrich began an extended pilot SVE test in the Building 1 area of VOC impact. The pilot test has proven SVE to be an effective technology at Parcel C and a full scale remediation system is currently being designed for the Building 1 area. A larger (15 well) SVE pilot test is being designed for the Building 2 zone of deep soil impact. Data from the pilot test will be evaluated to determine if full scale remediation is warranted in this area.

For groundwater, BRC selected enhanced biodegradation for treatment of the two areas with high concentrations (above approximately 5,000 µg/L TCE). Enhanced biodegradation was selected based on evidence on naturally-occurring biodegradation, lack of off-site impact, and compatibility with site redevelopment plans. Enhanced biodegradation would be accomplished by delivering nontoxic additives to the aquifer that serve as electron donors to enhance the rate of degradation of dissolved VOCs into benign compounds such as carbon dioxide and water.

Monitored natural attenuation has been selected for addressing the broader, low-concentration groundwater impacts. This strategy consists of ongoing monitoring and allowing naturally-occurring physical and chemical processes in the aquifer to achieve water quality improvements over time.



## 1.0 INTRODUCTION

Boeing Realty Corporation (BRC) is redeveloping the 170-acre Former C-6 Facility in Los Angeles, California (Figure 1). As part of the redevelopment process, BRC retained a multi-disciplinary team of environmental consultants to address subsurface environmental conditions beneath the Former C-6 Facility under the oversight of the California Regional Water Quality Control Board, Los Angeles Region (LARWQCB). The team includes Haley & Aldrich, Inc. and England Geosystem, Inc., who were responsible for completing a comprehensive Phase II investigation (begun by others) of vadose zone soils and groundwater. Based on the results of the Phase II investigation, BRC excavated shallow occurrences of impacted soil, completed a screening level health risk assessment, conducted a remediation pilot test, and began designing full scale remedial systems.

For the purposes of this environmental investigation, the Former C-6 Facility was divided into four parcels. The subject of this report, Parcel C, occupies approximately 50.5 acres in the east-central portion of the site (Figure 2). This report provides the results of the groundwater and vadose zone investigation, shallow soil excavations, and remediation plans for Parcel C of the Boeing Realty Corporation's Former C-6 Facility. Initially, the investigation focused on 232 environmental features (EFs) identified as being of potential concern based on a review of historical operations. The EFs included such areas as:

- paint booths,
- degreasers,
- chemical storage areas,
- underground storage tanks (USTs),
- sumps,
- clarifiers, and
- machining areas.

In addition, this investigation addressed "open areas" such as paved parking lots and large interior spaces where no EFs had been identified.

The purpose of this project was to identify and delineate the extent of impacted soils and groundwater, remove shallow (less than 12 feet) occurrences of impacted soil, initiate plans to deal with deep soil and groundwater, and to conduct a screening level risk assessment for the site. The investigation program included 169 soil gas samples, groundwater samples from 143 monitoring locations, and over 5,900 soil samples that were used to evaluate the nature and extent of subsurface impacts on Parcel C.



## 1.1 OVERVIEW OF THE FORMER C-6 FACILITY

### 1.1.1 History of the Former C-6 Facility

Aerial photographs indicate that the Site was farmland prior to the 1940s. The Former C-6 Facility was first developed by the Defense Plant Corporation in 1941 as part of an aluminum production plant and was operated by the Aluminum Corporation of America until late 1944. From 1944 until 1948 the Site was used for warehousing by the War Assets Administration. In 1948, the Columbia Steel Company acquired the Site. In March 1952, the US Navy purchased the Site and established Douglas Aircraft Company (DAC) as the contractor and operator of the facility for the manufacture of aircraft and aircraft parts. DAC purchased the Site from the Navy in 1970, DAC and its successor, McDonnell Douglas Corporation (created by the 1967 merger of DAC and McDonnell Aircraft Company), owned and operated the facility and continued manufacturing aircraft components until 1992. The Boeing Company took ownership of the Former C-6 Facility in 1997 when it merged with McDonnell Douglas Corporation.

Although most manufacturing operations ceased in 1992, a limited amount of assembly and warehousing continued through the mid-1990's. The Former C-6 Facility is currently closed and the buildings have been demolished.

The Site is surrounded by properties with widespread subsurface contamination: the Del Amo site is located to the east of the Former C-6 Facility; the Montrose site is to the south; and the International Light Metals (ILM) site is located to the west. There is evidence of some contamination having migrated onto the Former C-6 Facility from off-site sources, in particular on the west side of the property where an isolated zone of groundwater impact can be traced to the ILM site. Plans for soil and groundwater remediation must take into account and minimize the possibility of inducing migration of contaminants onto the site from these highly contaminated sources.

### 1.1.2 Description of Parcel C

Parcel C consisted of two large buildings (Buildings 1 and 2) and several smaller support structures (Figure 2). Building 1 was an approximately 250,000 square-foot structure used by DAC as a parts and records storage warehouse. The building was originally used as a carbon baking area when the facility was an aluminum production plant. Other activities have included metal finishing processes such as heat treating, milling, and pressing. During demolition a network of concrete structures was discovered beneath the foundation slab of Building 1, suspected to be cooling basins used in the aluminum production process. The structures were located along the northern and southern sides of the building and in the spaces between the three basement wings. They included concrete walls, sumps, chambers, footings, and foundations. The age and function of these structures are not known, but they are apparently not related to previous DAC or McDonnell Douglas operations.

Building 2 was an approximately 1,000,000 square-foot structure that was used by DAC for aircraft assembly and as a parts storage warehouse. Aerial photographs suggest that in the 1940's the building was used for aluminum production operations. The building was divided



into six east-west wings that were separated from each other by outdoor patio areas. Three of the patio areas were improved with the construction of two-story office structures.

Building 3 was an approximately 168,000 square-foot, three-story, brick office building that housed DAC administrative offices and laboratories. Prior to occupation by DAC, the structure was used by the Aluminum Corporation of America as a rectifier building. Aerial photographs from the 1940s show a large number of electrical transformers on the west side of the building.

Building 19 was an approximately 7,500 square-foot brick building that housed the security office and emergency services for the facility. Building 20 was the vehicle maintenance area and contained the following: a battery recharging area, a 3-stage clarifier draining a steam cleaning booth, an above ground motor oil tank, hydraulic lifts, and a condensation pit. Outside the building, there were underground storage tanks that dispensed unleaded and regular gasoline from a pump island.

Building 32 was built in the 1980s and contained a cafeteria and meeting hall. A materials transfer area, painting and paint storage, drains, oil storage and underground storage tanks were located immediately north, west, and southwest of Building 32, respectively. Building 66 was an approximately 200,000 square-foot warehouse that was constructed in 1972. Prior to its construction, this area of the Site was used as a storage yard. Other activities in the building included assembly of shipping supplies and light tooling operations.

## 1.2 APPROACH TO THE PHASE II SOIL INVESTIGATION

The overall objective of the Phase II investigation was to identify and delineate areas in which vadose zone soils and groundwater may have been impacted by organic and/or inorganic chemicals used at the facility and evaluate possible impacts on human health and/or groundwater quality.

In broad terms, the approach to the Phase II soil investigation was based on the types of operations known to have been conducted in different parts of the facility. Areas which, by the nature of the associated operations, may have impacted subsurface conditions were identified as EFs. Examples of EFs include USTs, sumps, chemical process areas, and chemical handling areas. Kennedy/Jenks identified most of the 232 EFs at the facility during the Phase I Environmental Site Assessment (Kennedy/Jenks, 1996); in addition, some EFs were identified during the planning stage of the Phase II soil investigation. There were 35 permitted USTs at the Former C-6 Facility which have all been removed and which were all classified as EFs. The investigation strategy for USTs focussed on collecting adequate data for completion of closure packages. Closure reports have been completed and submitted to the Los Angeles City Fire Department for 29 USTs and closure reports are in preparation for the remaining six USTs.

Large interior or exterior areas with no known record of chemical usage and, hence, no identified EFs, were considered "open areas." Examples of open areas include parking lots, dry storage areas, and roadways. Although they had no known record of chemical usage,



BRC elected to investigate open areas to minimize the likelihood of impacted areas being encountered unexpectedly during redevelopment.

The EFs and open areas were investigated by analyzing soil gas and soil matrix samples collected from soil gas probes, direct-push borings, and hollow stem auger drilling methods. The soil gas samples were analyzed for VOCs and the soil matrix samples were analyzed for a suite of organic and inorganic parameters selected based on the nature of the nearby former manufacturing or support operations. The specific investigative approach for each EF is presented in the Sampling and Analysis Plan and its supplements (Kennedy/Jenks, 2000a, 2000b; Ogden, 2000; Haley & Aldrich, 2001a, 2001b). As the results of the analyses were received from the analytical laboratories, they were evaluated and compared to soil gas screening concentrations (SGSCs) or soil field action levels (FALs), as appropriate. The derivation and use of these compound-specific SGSCs and FALs, which were developed specifically for the Phase II soil investigation, are described in supplements to the Sampling and Analysis Plan (Haley & Aldrich, 2001c, 2001d). In brief, they were used as a tool for assisting in impact delineation. Specifically, if a soil gas or soil matrix sample contained a constituent at a concentration above the corresponding SGSC or soil FAL, the EF or open area was evaluated to assess the need for additional "step-out/step-down" investigations.

Tests for physical soil parameters, such as moisture/density relationships, total organic carbon (TOC) content, and hydraulic conductivity were also performed at selected locations throughout the site to support risk assessment and potential future remedial design.

Once the buildings and foundation slabs were removed, there was better access to the underlying soil, and field staff could make more comprehensive observations than were possible from soil borings. This assessment confirmation phase of work enabled the team to identify zones of impact not previously encountered and to better delineate zones of impact already identified during the investigation phase.

A screening-level risk assessment (SRA) was also conducted to evaluate possible human health risk associated with the organic and inorganic chemicals identified in groundwater and the vadose zone. The SRA was based on conservative exposure scenarios and conservative assumptions regarding the chemical concentrations to which potential receptors may be exposed. The SRA was intentionally made conservative on the basis that further evaluation or remedial action would not be required if the results indicated that the chemicals identified in the vadose zone do not pose a significant risk to human health.



## 2.0 FIELD WORK AND ANALYTICAL PROGRAM

### 2.1 SOIL ASSESSMENT

The site has been extensively investigated for subsurface impacts: approximately 5,900 soil samples were collected at the site from over 1,200 distinct locations (either soil borings or surface grab samples; see Figure 3). Soil samples were collected from the surface to depths of 65 feet, which is the approximate depth of the water table. Soil samples were analyzed for some combination of the parameters listed below, depending on nature of the EF.

Soil Parameters	EPA Method No.
Volatile organic compounds (VOCs)	8260B
Total petroleum hydrocarbons (TPH)	8015(CC)
Semi-volatile organic compounds (SVOCs)	8270C
Polynuclear aromatic hydrocarbons (PAHs)	8310
Polychlorinated biphenyls (PCBs)	8082
Metals	6010B/6020/7000S
PH	9045

A few samples were also analyzed for the geotechnical characteristics listed below. This testing was performed in order to better characterize the soil stratigraphy and to provide physical data in support of future remediation design work.

Parameters	Method
Dry bulk density	ASTM D-2937
Moisture content	ASTM D-2937
Total organic carbon	Walkley-Black Method
Sieve analyses	ASTM D-422
Total porosity	ASTM D-854
Air filled porosity	ASTM D-854

A total of 169 soil gas samples were also collected at the Site and analyzed for VOCs using a truck-mounted direct-push drilling rig and a mobile laboratory.

### 2.2 GROUNDWATER ASSESSMENT

Groundwater at the site occurs at a depth of approximately 60 to 70 feet below ground surface (bgs) and is within the Bellflower aquiclude of the Lakewood Formation. The



Bellflower aquiclude consists of four primary units, the Bellflower B-Sand (60-90 feet bgs), the Middle Bellflower Mud (90-100 feet bgs), and the Bellflower C-Sand (100 to 115 feet bgs). Below the Bellflower C-Sand is the Lower Bellflower aquiclude and the Gage Aquifer.

BRC has installed 43 groundwater monitoring wells and collected over 100 samples from additional locations using hydropunch or temporary wells in the B-Sand and C-Sand units. No wells have been installed in the Gage aquifer. The groundwater monitoring wells are sampled biannually and are analyzed for VOCs and metals. Samples from some wells have also been analyzed for general mineral constituents (such as total dissolved solids, pH, chloride) and indicators of natural attenuation (such as dissolved oxygen, redox potential, sulfate, and nitrate).



### 3.0 ASSESSMENT RESULTS

#### 3.1 SOIL STRATIGRAPHY

Soil in the upper 20 to 50 feet consists predominantly of silts and clays. This fine-grained zone increases in thickness to the east. An east-dipping sandy zone underlies the fine-grained shallow soils. This sandy zone is generally 80 to 100 feet thick and is interbedded with numerous continuous and discontinuous layers of finer-grained sediments. The sandy unit is underlain by another fine-grained zone at a depth of approximately 110 to 120 feet bgs.

#### 3.2 SHALLOW SOIL RESULTS

The majority of the 232 identified EFs had no indication of significant impact in soil. A complete tally of results from all EFs is provided in the Soil Investigation Report (Haley & Aldrich, 2001e). Shallow soil (less than 12 feet) impacts were detected at 36 locations across the site (Table 1 and Figure 4). This includes the near-surface expression of the three deep zones discussed in Section 3.3.

Seven zones of soil impact were identified in or near Building 1. The largest zones in this area were the arsenic-bearing soil east of Building 1 (1-21) and petroleum hydrocarbons along the Knox Street Right-of-Way. Five other zones of shallow soil impact in Building 1 contained TPH, TCE, and/or PAHs.

There were 23 zones of shallow soil impact in or near Building 2. Sizable zones of impact in this area includes three TCE-impacted areas: the near-surface expression of the deep Building 2 VOC zone of impact (T-20) and two other areas as noted on Figure 4. Other sizeable zones of impact include copper and TPH in the Heat Treat Pit, TPH and VOCs at AK-11, arsenic at AN-19/23, and TPH, lead, and PAHs at AK-14/17. There are 16 other mostly small zones of impact scattered across Building 2. The most common constituents in these small zones are TPH and TCE, although other VOCs were encountered as well as inorganic compounds, PCBs, and PAHs.

Two small zones of shallow soil impact were found north of Building 3: one with lead (Q-23) and the other with TPH (R-23). Neither of these occurrences exceeded five feet in any dimension. One zone of soil impact was identified along the eastern wall of Building 20. This area (M/L-23) contained TPH, arsenic, and PAHs. Two zones of soil impact were identified north of Building 32. The eastern zone (2BB-5-20) contained elevated levels of arsenic and the western zone (32-4) contained TCE in the upper four feet of soil. Finally, one small zone of soil (66-9) impacted with arsenic was identified in Building 66.

As noted in Section 4, below, occurrences of shallow soil impact were evaluated using an iterative risk screening process. If the risk screening calculations indicated that a particular zone of impact posed a significant risk to human health, then the impacted soil from that



zone was excavated (Figure 10). If the risk screening indicated that a particular zone of impact did not pose a significant risk to human health, then the soil was left in place.

### 3.3 DEEP SOIL RESULTS

There are three primary occurrences of soil impact that extend into deeper soil. The occurrences of deep soil impact are referred to as the Knox Street Right-of-Way, the Building 1 area and the Building 2 area.

Impacts from the Knox Street Right-of-Way are the result of leaks from a fuel pipeline that extended approximately 600 feet east-west across Parcel C. A comprehensive investigation delineated the release area and found that the zone of impact extended approximately 370 feet. The width of the impact varied along the linear extent of the zone, ranging from 20 to 50 feet. The depth of TPH impact also varied from a minimum of seven feet to a maximum of approximately 26 feet bgs. Petroleum hydrocarbons in soil were measured at concentrations up to 23,000 mg/kg.

VOC impact in the Building 1 area appears to have originated from a former solvent storage area just north of Building 1 and south of Building 36 (Figures 5 and 6). TCE is the most abundant organic chemical with concentrations in soil up to 97,000 µg/kg; other detected organic chemicals include cis-1,2-dichloroethene (cis-1,2-DCE), 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), 1,1,1-trichloroethane (1,1,1-TCA) and toluene. Some of the detected organic chemicals are likely daughter products of TCE and 1,1,1-TCA suggesting active reductive dechlorination of chlorinated compounds. The TCE impact extends from the surface to the water table at approximately 65 feet bgs. Vertically, the highest concentrations are found at approximately 25 feet, then again in or near the capillary fringe. This concentration distribution appears to be related to the heterogeneous soil stratigraphy at the site, with higher concentrations remaining in the finer-grained units. Laterally, high concentrations of VOCs are limited to a relatively small area centered around soil borings 2BB-36-13 and PD-27, near the northeast corner of Building 1.

VOC impact in the Building 2 area may be related to metal finishing processes and releases from one or more clarifiers. Impacts in this area are more diffuse and may be the result of multiple releases throughout the western portion of the building (Figure 6). As with the Building 1 area, TCE is most abundant organic chemical with concentration up to 340,000 µg/kg. Other detected organic chemicals include TPH, cis-1,2-DCE, 1,1-DCE, 1,1-DCA, 1,1,1-TCA and toluene. Some of the detected organic chemicals are likely daughter products of TCE and TCA suggesting some active reductive dechlorination of chlorinated compounds in this area. Impacts extend from surface to the water table at approximately 65 feet bgs. Impacts extend laterally to a maximum extent of approximately 1,300 feet. Like the Building 1 area, the highest concentrations and greatest extent are at approximately 25 feet bgs, then again in or near the capillary fringe at about 60 feet bgs. The similarity in TCE distribution between the two major zones of impact supports our hypothesis that heterogeneity in the soil profile are a factor in controlling the distribution of VOCs in the subsurface. In general, higher concentrations remain in the finer-grained units.



### 3.4 GROUNDWATER RESULTS

VOCs and inorganic compounds have been detected in groundwater underlying Parcel C. The highest concentrations of VOCs are present in two locations beneath the zones of deep soil impact described above (the Building 1 area and the Building 2 area). Groundwater in the Building 1 area contains primarily TCE and 1,1-DCE (Figures 7 and 8 respectively) at concentrations up to 32,000 µg/L. Groundwater in this area is anaerobic, has low redox potential and shows evidence of biotic and abiotic reductive dechlorination.

Groundwater in the Building 2 area has been impacted primarily by TCE at concentrations up to 7,800 µg/L (Figure 7). Groundwater in this area of the site flows in a south-southeasterly direction. Unlike the Building 1 area, groundwater underlying Building 2 appears to be more oxygen-rich and has a positive redox potential.

Lower concentrations are found in a more widespread halo, largely emanating toward the south due to the southerly groundwater flow direction. Groundwater monitoring data collected at the site since 1987 suggests that the VOC plumes are relatively stable and have generally remained constant or declined in size over this period.

Inorganic compounds detected in groundwater include arsenic, barium, hexavalent chromium, lead, mercury, molybdenum, nickel, selenium, and zinc. None of the inorganic compounds detected in Parcel C were over the U.S. Environmental Protection Agency maximum contaminant level.

Groundwater under the Former C-6 Facility (largely outside of Parcel C) is also impacted from off-site sources along the southern and southeastern Facility boundary with benzene, chlorobenzene, and methylene chloride migrating from the Del Amo/Montrose properties, and along the western site boundary with TCE and hexavalent chromium from the ILM facility (Figure 9).



## 4.0 SUBSURFACE REMEDIATION

### 4.1 SHALLOW SOIL REMEDIATION

Approximately 9,735 cubic yards of impacted shallow soil were excavated from 33 locations on Parcel C (Table 1). Haley & Aldrich used an iterative risk screening procedure to evaluate where excavations were necessary to remove soil with concentrations of chemicals that posed a potential health risk. In order to evaluate the relative contribution of a particular zone of impact to overall risk, calculations were conducted with and without the maximum concentrations from that zone. If the zone of impact contributed significantly to an exceedence of acceptable risk levels (as approved by LARWQCB and Office of Environmental Health Hazard Assessment) then the impacted soil was targeted for removal (Figure 10). If the zone of impact had a negligible contribution to overall risk, then the impacted soil was left in place and was incorporated in the site-wide risk assessment.

In addition to the procedure described above, other excavations were carried out concurrently with demolition of the buildings. Shallow soil with elevated PID levels or visual indications of impact (e.g., discolored soils) was excavated and stockpiled temporarily on site, pending proper disposal. The iterative risk screening procedure was then applied to data from the excavation sidewall and/or bottom confirmation samples to evaluate the need for additional soil removal.

### 4.2 DEEP SOIL REMEDIATION

The objective of deep soil remediation is to reduce the mass of VOCs in the vadose zone that may be a source of further impact to groundwater. Where appropriate, BRC plans to deal with deep soil VOC impacts using soil vapor extraction (SVE). SVE was selected as the deep soil alternative due to its proven applicability at the site, cost-effectiveness for the removal of VOCs in the vadose zone, and ease of rapid deployment.

In July 2001, Haley & Aldrich began a 90-day pilot test in the Building 1 area of VOC impact. The pilot test configuration consists of vapor extraction wells completed in both the upper (12-23 feet bgs) and lower (35-60 feet bgs) portions of the vadose zone. The purpose of the pilot test is to collect information on VOC mass removal rates and subsurface radius of influence to evaluate the need for full-scale implementation.

Approximately 470 pounds of VOCs have been recovered from the vapor extraction wells from July 2 through August 3, 2001. Based on these results, Haley & Aldrich is designing a full scale SVE system for the Building 1 VOC impact area.

An extended-duration pilot test is also being implemented in the Building 2 VOC impact area to remove VOC mass and develop the area-specific design parameters. A total of 15 SVE wells are proposed for this pilot test. The Building 2 SVE pilot system installation is



currently in progress and operation is expected to commence in the fourth quarter of 2001. These data will then be used to evaluate if a full-scale system for this area is warranted.

#### 4.3 GROUNDWATER REMEDIATION

BRC evaluated numerous technologies to deal with VOCs in groundwater at the site. Technologies considered included enhanced biodegradation, in-situ chemical oxidation, dual-phase extraction, air sparging, as well as in-situ reactive barrier systems. Enhanced biodegradation has been selected for treatment of the Building 1 and Building 2 VOC source area plumes (defined as the regions with concentrations greater than approximately 5,000 µg/L; see Figure 6). Enhanced biodegradation was selected based on evidence on naturally-occurring biodegradation, no influence on off-site plumes, lack of deleterious effects, and compatibility with site redevelopment plans. Enhanced biodegradation would be accomplished by adding compounds that serve as electron donors to aid in the biodegradation of the VOCs, with the end products ultimately being carbon dioxide and water.

Pilot testing of enhanced biodegradation is currently under way for the Building 2 source area groundwater plume. A pilot test work plan was prepared and submitted to the LARWQCB for the addition of an aqueous molasses solution to the source area of the TCE plume. Pending LARWQCB approval, this pilot test is expected to commence in the fourth quarter of 2001 and will be completed sometime in 2002. The results of this pilot test will be used to develop the site-specific enhanced biodegradation design parameters.

Monitored natural attenuation has been selected for addressing the broader, low-concentration groundwater VOC impacts. This strategy consists of allowing naturally-occurring physical and chemical processes in the aquifer to achieve water quality improvements over time. Historical groundwater quality data from the site suggest biodegradation of VOCs is occurring naturally at the site, but at a slow rate. The groundwater plume appears to have reached a stable, steady-state condition and there appears to be no migration at the downgradient edge due to a balance between natural attenuation processes and the gradual delivery of VOCs from upgradient sources. Enhanced biodegradation would be very costly to implement across the widespread, low-concentration zones of impact. Given the steady-state plume condition, it does not appear to be necessary. In the event of changing hydrogeologic conditions that render the groundwater plume more mobile, enhanced biodegradation could be considered as a contingency measure.

## 5.0 SUMMARY AND CONCLUSIONS

This report summarizes the results of an extensive program of environmental investigations on Parcel C of the Boeing Realty Corporation (BRC) Former C-6 Facility in Los Angeles, California. The purpose of this project was to identify and delineate the extent of impacted soils and groundwater, remove shallow (less than 12 feet) occurrences of impacted soil, initiate plans to deal with deep soil and groundwater, and to conduct a screening level risk assessment for the Site. The program was conducted under the oversight of the LARWQCB. The investigation program included 169 soil gas samples, 143 groundwater sampling locations, and over 5,900 soil samples that were used to evaluate the nature and extent of subsurface impacts on Parcel C.

### 5.1 SOIL CONDITIONS

The majority of the 232 originally identified EFs had no indication of significant impact in soil. A complete tally of results from all EFs is provided in the Soil Investigation Report (Haley & Aldrich, 2001e). There were, however, a number of occurrences of shallow soil impact (less than 12 feet) and three occurrences of soil impact that extend into deeper soil. The occurrences of deep soil impact consist primarily of TPH, TCE and other volatile organic compounds and are referred to as the Knox Street Right-of-Way, the Building 1 area and the Building 2 area. The contaminants in shallow soil were more varied and consisted of one or more of the following: arsenic, lead, petroleum hydrocarbons, and/or PAHs.

Impacted shallow soil was excavated from 33 locations on Parcel C. A preliminary screening risk assessment was used to evaluate where excavations were necessary to remove soil with concentrations of chemicals that posed a potential health risk. Where necessary, BRC plans to deal with deep soil impacts using soil vapor extraction (SVE). SVE was selected as the deep soil remedy due to its proven applicability at the site, cost-effectiveness for the removal of VOCs in the vadose zone, and ease of rapid deployment. In July 2001, Haley & Aldrich began an extended pilot SVE test in the Building 1 area of VOC impact. The pilot test has proven SVE to be an effective technology at Parcel C and a full scale system is currently being designed for the Building 1 area. A larger (15 well) SVE pilot test is being designed for the Building 2 zone of deep soil impact. Data from the pilot test will be evaluated to determine if additional SVE operation is warranted in this area.

### 5.2 GROUNDWATER CONDITIONS

VOCs have also been detected in groundwater underlying Parcel C. The highest concentrations of VOCs occur beneath the zones of deep soil impact described above. Lower concentrations are found in a more widespread halo, largely emanating toward the south due to the southerly groundwater flow direction. Groundwater in the Building 1 area contains primarily TCE, with lesser amounts of 1,1,1-TCA, 1,1-DCE and other VOCs. Groundwater in the Building 2 area has been impacted primarily by TCE.



For groundwater, enhanced biodegradation has been selected for treatment of the two areas with high concentrations (above approximately 5,000 µg/L TCE). Enhanced biodegradation was selected based on evidence on naturally-occurring biodegradation, lack of off-site plume impact, lack of deleterious effects, and compatibility with site redevelopment plans. Enhanced biodegradation will be accomplished by delivering nontoxic additives to the aquifer that serve as electron donors to aid in the degradation of the VOCs into benign compounds such as carbon dioxide and water.

Monitored natural attenuation has been selected for addressing the broader, low-concentration groundwater impacts. This strategy consists of allowing naturally-occurring physical and chemical processes in the aquifer to achieve water quality improvements over time.

### 5.3 CONCLUSIONS

Parcel C has undergone a comprehensive investigation by collecting and analyzing soil, soil gas and groundwater samples from probes, borings, grab samples, and monitoring wells targeted at identified EFs and distributed throughout the surrounding open areas. Impacted soil and groundwater was encountered at Parcel C and are being dealt with through a variety of methods.

Key conclusions from this project are summarized here:

- Soil impacts within Parcel C have been adequately delineated to evaluate the associated potential risks to human health and/or the environment.
- Soil impacts are concentrated in two primary areas: the Building 1 area and the Building 2 area. Impacts in these areas consist of VOCs with TCE the predominant constituent. Toluene and 1,1,1,-TCA are also found in these areas.
- Other areas of impact in soil are present throughout Parcel C but consist of zones of relatively limited extent and low concentrations. The most common constituents in these scattered, small zones were petroleum hydrocarbons and VOCs, although some zones included inorganic compounds, PAHs, and PCBs.
- There is a good correlation between areas of high VOC concentrations in groundwater and deep impact in vadose zone soil, suggesting that the primary source areas contributing to VOC groundwater impact have been identified.
- A screening-level risk assessment was performed to evaluate risks to human health and the environment posed by soil impacts at Parcel C. Shallow soil impacts posing a significant risk to human health were remediated through excavation. Using this iterative risk screening method, approximately 9,735 cubic yards of soil were removed from 33 excavations.



## Summary of Soil and Groundwater Conditions

- Having completed the excavations, shallow soil (0 to 12 feet bgs) within Parcel C now meets LARWQCB and Office of Environmental Health Hazard Assessment-approved target risk levels for redevelopment as a commercial or industrial property and can be closed with no further investigation or remedial action.
- Deep soil VOC impacts in the Building 1 and Building 2 areas will be dealt with through the implementation of SVE remediation systems, as appropriate. Pilot testing is ongoing and an evaluation of the feasibility of full-scale implementation will be performed in the fourth quarter of 2001.
- Groundwater impacts and other isolated occurrences of deep soil impact will be managed as part of a site-wide groundwater remediation program which is currently under development.



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